CLAIMS

1. A method of controlling a vehicle, comprising:

providing a plurality of dynamic state inputs to a controller in a vehicle that is adapted to execute a plurality of control loops, each dynamic state input indicative of a dynamic state of the vehicle;

calculating an estimated steering behavior indicator using the controller and the dynamic state inputs during each of the plurality of control loops; wherein the estimated steering behavior indicator is adapted to provide an indication of the steering behavior of the vehicle during the dynamic state;

storing information related to the dynamic state inputs and the calculation of the estimated steering behavior indicator for a portion of the plurality of control loops; and

controlling the vehicle in response to the estimated steering behavior indicator.

2. The method of claim 1, wherein said calculating an estimated steering behavior indicator for a control loop comprises updating an estimated steering behavior indicator of a prior control loop using a dynamic state correction term that is a function of the dynamic state of the vehicle.

3. The method of claim 2, wherein the dynamic state correction term is a function of a weighting factor that varies as a function of the vehicle dynamic state.

4. The method of claim 3, further comprising:

determining the weighting factor as a function of a predetermined dynamic state indication parameter.

5. The method of claim 4, wherein the predetermined dynamic state indication parameter comprises a lateral velocity rate, a steering angle rate and a prior loop covariance related to the calculation of the prior loop estimated steering behavior indicator.

6. The method of claim 5, wherein said controlling the vehicle comprises providing an output from the controller to a yaw control system.

7. The method of claim 6, wherein the yaw control system is selected from a group consisting of a propulsion subsystem, a steering subsystem, a braking subsystem, and a suspension subsystem.

8. A method of controlling a vehicle, comprising:

sensing a plurality of dynamic state parameters of a vehicle;

providing a plurality of dynamic state inputs which are representative of the dynamic state parameters to a controller in the vehicle that is adapted to execute a plurality of control loops, each dynamic state input indicative of a dynamic state of the vehicle;

calculating an estimated steering behavior indicator using the controller and the dynamic state inputs during each of the plurality of control loops; wherein the estimated steering behavior indicator is adapted to provide an indication of the steering behavior of the vehicle during the dynamic state;

storing information related to the dynamic state inputs and the calculation of the estimated steering behavior indicator for a portion of the plurality of control loops; and

controlling the vehicle using the controller in response to the estimated steering behavior indicator.

9. The method of claim 8, wherein said calculating an estimated steering behavior indicator for a control loop (k_0) comprises updating an estimated steering behavior indicator of a prior control loop $(\hat{K}_{\mu}(k_{-1}))$ using a dynamic state correction term $(C(k_0))$ that is a function of the dynamic state of the vehicle according to the relationship:

$$\hat{K}_{\mu}(k_0) = \hat{K}_{u}(k_{-1}) + C(k_0)$$

10. The method of claim 9, wherein the dynamic state correction term comprises an estimation error related to the calculation of the estimated steering behavior indicator for the control loop.

11. The method of claim 10, wherein the estimation error is factored by an estimation error correction factor that is adapted to correct the estimation error as a function of the vehicle dynamic state.

12. The method of claim 11, wherein the estimation error correction factor is a function of a weighting factor that varies as a function of the vehicle dynamic state.

13. The method of claim 12, wherein the dynamic state inputs comprise a vehicle speed, a yaw rate, a steering angle and a lateral acceleration.

14. The method of claim 13, wherein calculating the estimated steering behavior indicator $\hat{K}_\mu(k_0)$ is performed according to the relationship comprising:

$$\hat{K}_\mu(k_0) = \hat{K}_\mu(k_{-1}) + F_{\varepsilon(k_0)}\varepsilon(k_0)$$

wherein:

$$\varepsilon(k_0) = \gamma(k_0) - \xi(k_{-1})\hat{K}_\mu(k_{-1}),$$

$$\gamma(k_0) = \delta_f(k_0)V_x(k_0) - L\dot{\psi}(k_0),$$

$$\xi(k_0) = a_y(k_0)V_x(k_0),$$

$$P(k_{-1}) = \frac{1}{\alpha(k_{-1})}\left[P(k_{-2}) - \frac{P^2(k_{-2})\xi^2(k_{-1})}{\alpha(k_{-1}) + \xi^2(k_{-1})P(k_{-2})}\right]$$

$$F_{\varepsilon(k_0)} = \frac{P(k_{-2})\xi(k_{-1})}{\alpha(k_{-1}) + \xi^2(k_{-1})P(k_{-2})},$$

and:

k_0 is one of the plurality of control loops,

k_{-1} is a first prior control loop, wherein k_1 precedes k_0,

k_{-2} is a second prior control loop, wherein k_2 precedes k_1,

L comprises a wheelbase of the vehicle,

$P(k_{-1})$ is a covariance term calculated for the first prior control loop,

$P(k_{-2})$ is a covariance term calculated for the second prior control loop,

$\alpha(k_{-1})$ is a weighting factor determined for the first prior control loop,

$\alpha(k_{-2})$ is a weighting factor determined for the second prior control loop.

15. The method of claim 14, further comprising determining the weighting factor as a function of a predetermined dynamic state indication parameter.

16. The method of claim 15, wherein the predetermined dynamic state indication parameter comprises a lateral velocity rate, a steering angle rate and a prior loop covariance related to the calculation of the prior loop estimated steering behavior indicator.

17. The method of claim 16, further comprising:
determining the lateral velocity rate during the control loop;
determining the steering angle rate $(SAR(k_0))$ during the control loop; and
determining the prior loop covariance.

18. The method of claim 17, wherein determining a steering angle rate $(SAR(k_0))$ comprises calculating an estimated steering angle rate $(SAR_{est}(k_0))$.

19. The method of claim 18, wherein calculating the estimated steering angle rate is performed according to the relationship comprising:

$$SAR_{est}(k_0) = SAR_{est}(k_{-1}) + T_{k_0}(g_2)(\delta_f(k_0) - SA_{est}(k_0))$$

where:

$$SA_{est}(k_0) = (1 - T_{k_0}(g_1))(SA_{est}(k_{-1})) + T_{k_0}(g_1)(\delta_f(k_0)) + T_{k_0}(SAR_{est}(k_{-1})),$$

$$g_1 = 2(\zeta)(2\pi(fn)),$$

$$g_2 = (2\pi(fn))^2$$

and:

fn is a frequency coefficient,

ζ is a damping coefficient,

T_{k_0} is a sampling time interval of the control loop (k_0),

$SA_{est}(k_0)$ is a steering angle estimate for the control loop (k_0),

$SA_{est}(k_{-1})$ is a steering angle estimate for the control loop (k_{-1}),

$SAR_{est}(k_{-1})$ is a steering angle rate estimate for a control loop (k_{-1}).

20. The method of claim 17, wherein the weighting factor $\alpha(k_0)$ has a value during the control loop which is determined by:

selecting a covariance threshold (P_{TH}), a lateral velocity rate threshold $(\dot{V}_{yd_{TH}})$, a first steering angle rate threshold (SAR_{TH_1}), a second steering angle rate threshold (SAR_{TH_2}), a first timer count threshold $(t_{1_{TH}})$ and a second timer count threshold $(t_{2_{TH}})$;

initializing a first timer to a first timer initial value and a second timer to a second timer initial value,

setting the value of the weighting factor to a first value $\alpha_1(k_0)$;

determining a first condition, wherein the first condition is satisfied if $|SAR(k_0)| \leq SAR_{TH_1}$, and if the first condition is satisfied, incrementing the first timer while the first condition is satisfied to determine a first timer count $(t_1(k_0))$, and if the first condition is or becomes not satisfied, returning to initializing the first timer and the second timer;

determining a second condition while the first condition is satisfied, wherein the second condition is satisfied if $t_1(k_0) \geq t_{1_{TH}}$;

determining a third condition, wherein the third condition is satisfied if the second condition is satisfied, or $P(k_{-1}) > P_{TH}$, or $|\dot{V}_{yd}(k_0)| > \dot{V}_{yd_{TH}}$;

if the third condition is satisfied, calculating a second value for the weighting factor $(\alpha_2(k_0))$ as a function of the estimation error, the lateral acceleration and the vehicle speed;

if the third condition is not satisfied, determining a fourth condition, wherein if $|SAR_{est}(k_0)| < SAR_{TH\_2}$, the fourth condition is satisfied, and if the fourth condition is satisfied, incrementing the second timer while the fourth condition is satisfied to determine a second timer count $(t_2(k_0))$, and if the fourth condition is or becomes not satisfied, the second timer is reset to the second timer initial value;

if the fourth condition is satisfied, determining a fifth condition while the fourth condition is satisfied, wherein the fifth condition is satisfied if $(t_2(k_0) \geq t_{2\_TH}$, and wherein if the fifth condition is satisfied, setting the value of the weighting factor to a third value $(\alpha\ (k_0) = \alpha_3)$, where $\alpha_3 < \alpha_1$, and wherein if the fifth condition is not satisfied, setting the value of the weighting factor to a fourth value $(\alpha\ (k_0) = \alpha_4)$.

21. The method of claim 20, wherein calculating a second value for the weighting factor $(\alpha_2(k_0))$ is performed according to the relationship comprising:

$$\alpha_2(k_0) = 1 - \alpha'\left[\frac{\varepsilon^2(k_0)}{1+\xi^2(k_{-1})P(k_{-2})}\right],$$

and:

α' is a vehicle weighting factor.

22. The method of claim 21, wherein $\alpha_1(k_0) = 1$.

23. The method of claim20, wherein said step of controlling the vehicle comprises providing an output from the controller to a yaw control system.

24. The method of claim 23, wherein the yaw control system is selected from a group consisting of a propulsion subsystem, a steering subsystem, a braking subsystem, and a suspension subsystem.

25. An integrated chassis control system for a vehicle, comprising:

a controller which is adapted to execute a plurality of control loops, and receive a plurality of dynamic state inputs that are indicative of a dynamic state of a vehicle during its operation and determine a steering behavior indicator from the dynamic state inputs that is indicative of a dynamic state of the vehicle in conjunction with the control loops; and

a control system that is adapted to communicate with said controller and provide control of the dynamic state of the vehicle in response to the steering behavior indicator.

26. The system of claim 25, wherein the dynamic state inputs comprise a speed input, a yaw rate input, a steering angle input and a lateral acceleration input.

27. The system of claim 26, wherein the estimated steering behavior indicator for a control loop is determined by updating an estimated steering behavior indicator of a prior control loop using a dynamic state correction term that is a function of the dynamic state of the vehicle.

28. The system of claim 27, wherein the dynamic state correction term is a function of a weighting factor that varies as a function of a dynamic state indication parameter.

29. The system of claim 28, wherein the predetermined dynamic state indication parameter comprises a lateral velocity rate, a steering angle rate and a prior loop covariance related to the calculation of the prior loop estimated steering behavior indicator.

30. The system of claim 29, wherein the control system comprises a yaw control system.

31. The method of claim 30, wherein the yaw control system is selected from a group consisting of a propulsion subsystem, a steering subsystem, a braking subsystem, and a suspension subsystem.